

- (i) an attenuated live mutant bacterium having a genome wherein a native gene having a function of ferric uptake regulation (fur gene) has been modified by mutation whereby expression of a gene product corresponding to said fur gene is regulated independently of the iron concentration in the environment of the bacterium; and
- (ii) a non-viable preparation comprising bacterial membrane antigens from cultured cells of a mutant bacterium having a genome wherein a native gene having a function of ferric uptake regulation (fur gene) has been modified by mutation whereby expression of a gene product corresponding to said fur gene is regulated independently of the iron concentration in the environment of the bacterium; together with:-
 - (b) a pharmaceutically acceptable diluent or carrier.
- 26. The vaccine composition of claim 25, wherein said mutant bacterium comprises Neisseria meningitidis, Neisseria gonorrhoeae, Helicobacter pylori, Salmonella typhi, Salmonella typhimurium, or E. coli.
- 27. The vaccine composition of claim 25, wherein said non-viable preparation comprising bacterial membrane antigens is obtained by isolating bacterial membrane vesicles from said cultured cells of said mutant bacterium.
- 28. An attenuated mutant bacterium having a genome wherein a native fur gene, having a function of ferric uptake regulation, has been modified by mutation whereby expression of a gene product corresponding to said fur gene is regulated independently of the iron concentration in the environment of the bacterium.
 - 29. The attenuated mutant bacterium of claim 28 which is a gram-negative bacterium.
- 30. The attenuated mutant bacterium of claim 28, wherein the mutant bacterium comprises a Neisseria meningitidis, Neisseria gonorrhoeae, Helicobacter pylori, Salmonella typhi, Salmonella typhimurium, enteropathogenic E. coli (EPEC), enteroinvasive E. coli (EIEC), enterotoxigenic E. coli (ETEC), enterohaemorrhagic E. coli (EHEC), verotoxigenic E. coli (VTEC), Vibrio cholerae, Shigella spp., Haemophilus influenzae, Bordetella pertussis or Pseudomonas aeruginosa species.

D

- WDN/SAS:an 12/9/99 5673-53922
- 31. The attenuated mutant bacterium of claim 28, wherein the mutant bacterium comprises a Neisseria meningitidis or Neisseria gonorrhoeae species.
- 32. The attenuated mutant bacterium of claim 28, which has a mutation of a gene essential for production of a bacterial metabolite or catabolite not produced by a human or animal.
- 33. The attenuated mutant bacterium of claim 28, which has an attenuating mutation of a gene selected from aro, asd, pur and pyr genes.
- 34. The attenuated mutant bacterium of claim 33, wherein said mutation is of a gene selected from aroA, aroB, aroC, aroD, aroL, purA, purB, purE, pyrA, pyrB and pyrE.
 - 35. The attenuated mutant bacterium of claim 28, which has a recA mutation.
- 36. The attenuated mutant bacterium of claim 28, which has a mutation by which expression of a toxin gene has been modified or eliminated.
- 37. The attenuated mutant bacterium of claim 28, which has a mutation at a site homologous to the E. coli minB locus.
- 38. The attenuated mutant bacterium of claim 28, which has a mutation in a gene involved in uptake of DNA.
- 39. The attenuated mutant bacterium of claim 38, which is of a species selected from N. meningitidis and N. gonorrhoeae, and wherein said mutation in said gene involved in uptake of DNA is a *comA* mutation.
- 40. The attenuated mutant bacterium of claim 28, which is of a species selected from N. meningitidis or N gonorrhoeae and which has a mutation in the galE gene.
- 41. The attenuated mutant bacterium of claim 40, which further has a mutation in the opc gene to modify or eliminate expression of opc protein.

- 42. An attenuated mutant bacterial strain of the species *N. meningitidis* which has a genotype selected from:
 - (a) mutation of aroB, lac:fur fusion, and mutation of recA;
 - (b) mutation of aroB, mutation of galE, lac:fur fusion, and mutation of recA;
 - (c) mutation of aroL, lac:fur fusion, and mutation of recA; and
 - (d) mutation of aroL, mutation of galE, lac:fur fusion, and mutation of recA.
- 43. The attenuated mutant bacterial strain of the species *N. meningitidis*, according to claim 42, which also has at least one characteristic selected from: a *minB* mutation; an RTX negative phenotype; and an opc gene mutation whereby expression of said opc gene has been modified or eliminated.
- 44. A preparation of membrane vesicles obtained by isolating bacterial membrane vesicles from cultured cells of a mutant bacterium having a genome wherein a native *fur* gene having a function of ferric uptake regulation has been modified by mutation whereby expression of a gene product corresponding to said *fur* gene is regulated independently of the iron concentration in the environment of the bacterium.
- 45. A method of treating a subject which is a human or non-human animal, said method comprising vaccinating said subject with the vaccine composition of claim 25 thereby to stimulate an immune response against said bacterium.
- 46. A method of manufacturing a vaccine composition which comprises the attenuated mutant bacterium of claim 28, which process comprises:
- (a) inoculating said attenuated mutant bacterium into a culture vessel containing a nutrient medium suitable for growth of said bacterium;
 - (b) culturing said bacterium;
 - (c) recovering bacteria from the culture; and
 - (d) mixing said bacteria with a pharmaceutically acceptable diluent or carrier.
- 47. A method of producing the attenuated mutant bacterium of claim 28, said method comprising introducing, into a genome of an attenuated bacterium, a mutation of a native bacterial *fur* gene having a function of ferric uptake regulation, whereby expression of a gene product corresponding to said *fur* gene is regulated independently of the iron concentration in the environment of the bacterium.